

IN THE DESCRIPTION

Kindly make the following amendments to the description:

[03] Variable optical attenuators, such as the one illustrated in Figure 1 and disclosed in United States Patent No. 4,410,238 issued October 18, 1983 to Eric Hanson, include a first birefringent crystal 32, with an optic axis 34 at an angle 40 from a front face thereof, for dividing an input beam of light 36 into two ~~to~~ orthogonally polarized sub-beams 37 and 38; a liquid crystal cell 31 for adjusting the polarization of the two sub-beams 37' and 38'; and a second birefringent crystal 33, with an optic axis 34 at an angle 40 from a front face 35, for dividing each sub-beam 37' and 38' into orthogonally polarized components 43, 47 and 44, 48, respectively, and for recombining components 43 and 44 at output port 45, while spilling off unwanted light 47' and 48'. Air gaps 51 separate the first and second birefringent crystals 32 and 33 from the liquid crystal cell 31.

[07] Accordingly, the present invention relates to a A variable optical attenuator device comprising:

[28] With reference to Figures 2 to 7, the variable optical attenuator 100 according to the present invention includes a first polarization beam splitter, preferably in the form of a first birefringent crystal 101, receiving an input beam of light from an optical waveguide 102. The first birefringent crystal 101 divides the input beam of light into two orthogonally polarized sub-beams 103 and 104. For illustration purposes, sub-beam 103 is horizontally polarized, while sub-beam 104 is vertically polarized, although other variations are possible depending on the orientation of the optical axis of the first birefringent crystal 101. A first lens 106 is disposed to receive the first and second sub-beams 103 and 104 on opposite sides of the optical axis 105 thereof, whereby the first and second sub-beams 103 and 104 are redirected as collimated beams along converging paths, which crisscross and then diverge. A variable polarization rotator 107, preferably in the form of a twisted nematic liquid crystal cell, is positioned in the paths of the sub-beams 103 and 104, preferably a focal length from, i.e. in the focal plane of, the first lens 106, so that both sub-beams 103 and 104 enter the variable polarization rotator 107 at the same point, which minimizes any PDL caused by anisotropy in the liquid crystal. Depending on the mode field diameter (MFD) used and the thickness of the birefringent crystal 101, the sub-

beams 103 and 104 will be very close to intersecting after passing through the first lens 106, so the PDL will be greatly reduced even if the variable polarization rotator 107 is not placed exactly at the focal plane of the lens 106. The variable polarization rotator 107, under the control of variable controller 112, changes the state of polarization (SOP) of the sub-beams 103 and 104 to a desired state depending upon the amount of output light required. The sub-beams 103 and 104, with potentially altered SOPs, exit the variable polarization rotator 107, propagate along diverging paths in collimated space, and intersect a second lens 108 on opposite sides of the optical axis 110 thereof. The second lens 108 focuses the sub-beams 103 and 104 from collimated space to converging space, and directs them along parallel paths to a polarization beam combiner, in the form of a second birefringent crystal 109. Ideally the sub-beams 103 and 104 enter and exit the lenses 106 and 108 symmetrical with respect to the optical axes thereof 105 and 110, respectively, to enable all of the elements of the attenuator 100 to be aligned therealong. The polarization beam combiner 109 recombines the desired amount of light from each sub-beam 103 and 104 for output to an output waveguide 111, while spilling-off any unwanted light.

[29] Figures 3 and 4 illustrate the variable optical attenuator 100 providing 100% attenuation. At Position A the input beam of light is illustrated as having mixed polarizations entering into the first birefringent crystal 101. By Position B, the first and second sub-beams 103 and 104 are orthogonally polarized and spatially separated. The first lens 106 redirects the first and second sub-beams 103 and 104 along paths converging to the same point of entry into the variable polarization rotator 107 (Position C). In the example given in Figure 3 and 4, the variable polarization rotator 107 provides no polarization rotation, therefore the sub-beams 103 and 104 maintain the same polarization therethrough to Position D, but with a slight spatial separation. By Position E, the sub-beams 103 and 104 have traveled along diverging paths (in collimated space) resulting in even more spatial separation. Since the states of polarization of the first and second sub-beams 103 and 104 were not altered by the variable polarization rotator 107, the first sub-beam 103 continues through the second birefringent crystal 109 parallel to the output waveguide 111, while the second sub-beam 104 is walked off away from the output waveguide 111. Accordingly, the input light is fully attenuated, as no ~~not~~ light is directed to the output waveguide 111.